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AMENDMENTS TO THE CLAIMS

All pending claims are produced below.

1. (Original) A method for robust single-pass variable bit rate video encoding, the method comprising:

determining a buffer size for keeping track of over/underused bits generated during the encoding of a video sequence, the buffer size being a function of at least a target bit rate for the video sequence and a length of the video sequence;

initializing the buffer to a default initial fullness; and

for each frame of the video sequence, performing the following steps:

allocating a number of bits to the frame;

determining a quant with which to encode the frame, the quant being a function of at least the buffer's fullness;

encoding the frame according to the determined quant; and

updating the fullness of the buffer based on any over/underused bits for the frame.

2. (Original) The method of claim 1 wherein frames in a GOP are encoded, the method further comprising:

allocating a segment of the buffer for keeping track of over/underused bits for I frames, a segment for keeping track of over/underused bits for P frames and a segment for keeping track of over/underused bits for B frames;

initializing each segment of the buffer to a default initial fullness;

determining a number of I frames per GOP, a number of P frames per GOP and a number of B frames per GOP, based on a nominal GOP pattern;

for each frame of the video sequence, determining the quant with which to encode that frame as a function of at least the fullness of the segment of the buffer for that frame type; and

for each GOP of the video sequence, performing the following steps:

before encoding any frame of that GOP, calculating a GOP bit target for that GOP, the GOP bit target being a function of at least the number of I frames, P frames and B frames per GOP, the target bit rate for the video sequence and any bits carried over from a last encoded GOP;

after encoding each frame of that GOP, calculating over/underused bits by subtracting allocated bits from actual used bits, adding any over/underused bits to an appropriate buffer segment to an extent to which the appropriate buffer segment is not over/underflowed and storing any over/underflow bits in a counter; and

after encoding all frames of that GOP, redistributing over/underused bits between the segments of the buffer as a function of at least a total number of over/underused bits in the buffer and the number of I frames, P frames and B frames per GOP and storing an indication of a number of over/underused bits with respect to the allocated target bits for that GOP to carry over to the next GOP.

3. (Original) The method of claim 2 further comprising:

storing information concerning over/underused of at least some encoded frames by frame type; and

using the stored information concerning over/underused bits of frames of a specific frame type in determining quants with which to encode frames of that type.

4. (Original) The method of claim 3 wherein storing information concerning over/underused of at least some encoded frames by frame type further comprises:

storing information concerning over/underused of a specific number of most recently encoded I frames, P frames and B frames.

5. (Original) The method of claim 1 or 2, wherein:

the buffer is a virtual buffer storing information concerning a number of over/underused bits, without storing the over/underused bits themselves.

6. (Original) The method of claim 2 further comprising:

before encoding any frame, initializing to a default initial value at least one parameter from a group of parameters consisting of:

a base quant envelope for each frame type;

a base quant envelope control for each frame type;

ratio information concerning frame types; and

a frame complexity parameter for each frame type.

7. (Original) The method of claim 2 further comprising:

for each GOP of the video sequence, before encoding any frame of that GOP, determining whether the fullness of each segment of the buffer is at least at an associated minimal value; and

responsive to the fullness of a segment of the buffer not being at least at the associated minimal value, adjusting the fullness of the segment accordingly.

8. (Original) The method of claim 2 wherein allocating a number of bits to a frame further comprises:

allocating bits to the frame according to a modified TM5 reference model, the allocation utilizing at least one an additional parameter from a group of parameters consisting of:

at least one frame complexity parameter for a last encoded frame of a frame type;

a GOP bit target for the GOP being processed;

ratio information concerning frame types within a GOP;

the number of I frames per GOP;

the number of P frames per GOP; and

the number of B frames per GOP.

9. (Original) The method of claim 1 wherein allocating a number of bits to a frame further comprises:

allocating bits to the frame according to a TM5 reference model.

10. (Original) The method of claim 2 wherein determining a quant with which to encode the frame further comprises:

prior to determining the quant, normalizing the fullness of the segment corresponding to the type of frame to encode, based on at least the segment size and the non-normalized segment fullness; and

determining the quant as a function of at least a base quant envelope and the normalized segment fullness.

11. (Original) The method of claim 10 further comprising:

adjusting the determined quant based on the frame being a transition frame in the video sequence.

12. (Original) The method of claim 1 further comprising:

after encoding each frame of the video sequence, determining whether the encoding of that frame causes a VBV buffer underflow;

responsive to determining that the encoding of that frame causes a VBV buffer underflow, adjusting the quant used to encode the frame; and

re-encoding the frame with the adjusted quant so as to eliminate the VBV buffer underflow.

13. (Original) The method of claim 2 further comprising:

after encoding each frame of the video sequence, updating at least one parameter from a group of parameters consisting of:

a base quant envelope for the encoded frame type;

ratio information concerning frame types; and

a frame complexity parameter for the encoded frame type.

14. (Original) The method of claim 13 further comprising:

updating the base quant envelope for the encoded frame type, as a function of at least a base quant envelope control for the encoded frame type, an indicator of the over/underflow bit status of the encoded frame, and the non-updated base quant envelope for the encoded frame type.

15. (Original) The method of claim 10 further comprising:

adding the counter of unallocated over/underflow bits to the buffer segment corresponding to the type of frame to encode, to an extent that the buffer segment is not overflowed or underflowed; and

retaining any over/underflow bits that cannot be added to the segment in the counter.

16. (Original) A computer system for robust single-pass variable bit rate video encoding, the computer system comprising:

means for determining a buffer size for keeping track of over/underused bits generated during the encoding of a video sequence, the buffer size being a function of at least a target bit rate for the video sequence and a length of the video sequence;

means for initializing the buffer to a default initial fullness; and

means for performing the following steps for each frame of the video sequence:

allocating a number of bits to the frame;

determining a quant with which to encode the frame, the quant being a function of at least the buffer's fullness;

encoding the frame according to the determined quant; and

updating the fullness of the buffer based on any over/underused bits for the frame.

17. (Original) The computer system of claim 16 wherein frames in a GOP are encoded, the computer system further comprising:

means for allocating a segment of the buffer for keeping track of over/underused bits for I frames, a segment for keeping track of over/underused bits for P frames and a segment for keeping track of over/underused bits for B frames;

means for initializing each segment of the buffer to a default initial fullness;

means for determining a number of I frames per GOP, a number of P frames per GOP and a number of B frames per GOP, based on a nominal GOP pattern;

means for determining the quant with which to encode that frame as a function of at least the fullness of the segment of the buffer for that frame type for each frame of the video sequence; and

means for performing the following steps for each GOP of the video sequence:

before encoding any frame of that GOP, calculating a GOP bit target for that GOP, the GOP bit target being a function of at least the number of I frames, P frames and B frames per GOP, the target bit rate for the video sequence and any bits carried over from a last encoded GOP;

after encoding each frame of that GOP, calculating over/underused bits by subtracting allocated bits from actual used bits, adding any over/underused bits to an appropriate buffer segment to an extent to which the appropriate buffer segment is not over/underflowed and storing any over/underflow bits in a counter; and

after encoding all frames of that GOP, redistributing over/underused bits between the segments of the buffer as a function of at least a total number of over/underused bits in the buffer and the number of I frames, P frames and B frames per GOP and storing an indication of a number of over/underused bits with respect to the allocated target bits for that GOP to carry over to the next GOP.

18. (Original) The computer system of claim 17 further comprising:

means for storing information concerning over/underused of at least some encoded frames by frame type; and

means for using the stored information concerning over/underused bits of frames of a specific frame type in determining quants with which to encode frames of that type.

19. (Original) The computer system of claim 18 wherein the means for storing information concerning over/underused of at least some encoded frames by frame type further comprises:

means for storing information concerning over/underused of a specific number of most recently encoded I frames, P frames and B frames.

20. (Original) The computer system of claim 16 or 17, wherein:

the buffer is a virtual buffer storing information concerning a number of over/underused bits, without storing the over/underused bits themselves.

21. (Original) The computer system of claim 17 wherein the means for determining a quant with which to encode the frame further comprises:

means for, prior to determining the quant, normalizing the fullness of the segment corresponding to the type of frame to encode, based on at least the segment size and the non-normalized segment fullness; and

means for determining the quant as a function of at least a base quant envelope and the normalized segment fullness.

22. (Original) The computer system of claim 21 further comprising:

means for adding the counter of unallocated over/underflow bits to the buffer segment corresponding to the type of frame to encode, to an extent that the buffer segment is not overflowed or underflowed; and

means for retaining any over/underflow bits that cannot be added to the segment in the counter.

23. (Original) The computer system of claim 16 further comprising:

means for, after encoding each frame of the video sequence, determining whether the encoding of that frame causes a VBV buffer underflow;

means for, responsive to determining that the encoding of that frame causes a VBV buffer underflow, adjusting the quant used to encode the frame; and

means for re-encoding the frame with the adjusted quant so as to eliminate the VBV buffer underflow.

24. (Original) A computer system for robust single-pass variable bit rate video encoding, the computer system comprising:

a portion configured to determine a buffer size for keeping track of over/underused bits generated during the encoding of a video sequence, the buffer size being a function of at least a target bit rate for the video sequence and a length of the video sequence;

a portion configured to initialize the buffer to a default initial fullness; and

a portion configured to perform the following steps for each frame of the video sequence:

allocate a number of bits to the frame;

determine a quant with which to encode the frame, the quant being a function of at least the buffer's fullness;

encode the frame according to the determined quant; and

update the fullness of the buffer based on any over/underused bits for the frame.

25. (Original) The computer system of claim 24 wherein frames in a GOP are encoded, the computer system further comprising:

a portion configured to allocate a segment of the buffer for keeping track of over/underused bits for I frames, a segment for keeping track of over/underused bits for P frames and a segment for keeping track of over/underused bits for B frames;

a portion configured to initialize each segment of the buffer to a default initial fullness;

a portion configured to determine a number of I frames per GOP, a number of P frames per GOP and a number of B frames per GOP, based on a nominal GOP pattern;

a portion configured to determine the quant with which to encode that frame as a function of at least the fullness of the segment of the buffer for that frame type for each frame of the video sequence; and

a portion configured to perform the following steps for each GOP of the video sequence:

before encoding any frame of that GOP, calculate a GOP bit target for that GOP, the GOP bit target being a function of at least the number of I frames, P frames and B frames per GOP, the target bit rate for the video sequence and any bits carried over from a last encoded GOP;

after encoding each frame of that GOP, calculate over/underused bits by subtracting allocated bits from actual used bits, add any over/underused bits to an appropriate buffer segment to an extent to which the appropriate buffer segment is not over/underflowed and store any over/underflow bits in a counter; and

after encoding all frames of that GOP, redistribute over/underused bits between the segments of the buffer as a function of at least a total number of over/underused bits in the buffer and the number of I frames, P frames and B frames per GOP and store an indication of a number of over/underused bits with respect to the allocated target bits for that GOP to carry over to the next GOP.

26. (Original) The computer system of claim 25 further comprising:

a portion configured to store information concerning over/underused of at least some encoded frames by frame type; and

a portion configured to use the stored information concerning over/underused bits of frames of a specific frame type in determining quants with which to encode frames of that type.

27. (Original) The computer system of claim 26 wherein the portion configured to store information concerning over/underused of at least some encoded frames by frame type further comprises:

a portion configured to store information concerning over/underused of a specific number of most recently encoded I frames, P frames and B frames.

28. (Original) The computer system of claim 24 or 25 wherein:

the buffer is a virtual buffer storing information concerning a number of over/underused bits, without storing the over/underused bits themselves.

29. (Original) The computer system of claim 25 wherein the portion configured to determine a quant with which to encode the frame further comprises:

a portion configured to, prior to determining the quant, normalize the fullness of the segment corresponding to the type of frame to encode, based on at least the segment size and the non-normalized segment fullness; and

a portion configured to determine the quant as a function of at least a base quant envelope and the normalized segment fullness.

30. (Original) The computer system of claim 29 further comprising:

a portion configured to add the counter of unallocated over/underflow bits to the buffer segment corresponding to the type of frame to encode, to an extent that the buffer segment is not overflowed or underflowed; and

a portion configured to retain any over/underflow bits that cannot be added to the segment in the counter.

31. (Original) The computer system of claim 24 further comprising:

a portion configured to, after encoding each frame of the video sequence, determine whether the encoding of that frame causes a VBV buffer underflow;

a portion configured to, responsive to determining that the encoding of that frame causes a VBV buffer underflow, adjust the quant used to encode the frame; and

a portion configured to re-encode the frame with the adjusted quant so as to eliminate the VBV buffer underflow.

32. (Original) A computer readable medium containing a computer program product for robust single-pass variable bit rate video encoding, the computer program product comprising:

program code for determining a buffer size for keeping track of over/underused bits generated during the encoding of a video sequence, the buffer size being a function of at least a target bit rate for the video sequence and a length of the video sequence;

program code for initializing the buffer to a default initial fullness; and

program code for performing the following steps for each frame of the video sequence:

allocating a number of bits to the frame;

determining a quant with which to encode the frame, the quant being a function of at least the buffer's fullness;

encoding the frame according to the determined quant; and

updating the fullness of the buffer based on any over/underused bits for the frame.

33. (Original) The computer program product of claim 32 wherein frames in a GOP are encoded, the computer program product further comprising:

program code for allocating a segment of the buffer for keeping track of over/underused bits for I frames, a segment for keeping track of over/underused bits for P frames and a segment for keeping track of over/underused bits for B frames;

program code for initializing each segment of the buffer to a default initial fullness;

program code for determining a number of I frames per GOP, a number of P frames per GOP and a number of B frames per GOP, based on a nominal GOP pattern;

program code for determining the quant with which to encode that frame as a function of at least the fullness of the segment of the buffer for that frame type for each frame of the video sequence; and

program code for performing the following steps for each GOP of the video sequence:

before encoding any frame of that GOP, calculating a GOP bit target for that GOP, the GOP bit target being a function of at least the number of I frames, P frames and B frames per GOP, the target bit rate for the video sequence and any bits carried over from a last encoded GOP;

after encoding each frame of that GOP, calculating over/underused bits by subtracting allocated bits from actual used bits, adding any over/underused bits to an appropriate buffer segment to an extent to which the appropriate buffer segment is not over/underflowed and storing any over/underflow bits in a counter; and

after encoding all frames of that GOP, redistributing over/underused bits between the segments of the buffer as a function of at least a total number of over/underused bits in the buffer and the number of I frames, P frames and B frames per GOP and storing an indication of a number of over/underused bits with respect to the allocated target bits for that GOP to carry over to the next GOP.

34. (Original) The computer program product of claim 32 further comprising:

program code for storing information concerning over/underused of at least some encoded frames by frame type; and

program code for using the stored information concerning over/underused bits of frames of a specific frame type in determining quants with which to encode frames of that type.

35. (Original) The computer program product of claim 34 wherein the program code for storing information concerning over/underused of at least some encoded frames by frame type further comprises:

program code for storing information concerning over/underused of a specific number of most recently encoded I frames, P frames and B frames.

36. (Original) The computer program product of claim 32 or 33 wherein:

the buffer is a virtual buffer storing information concerning a number of over/underused bits, without storing the over/underused bits themselves.

37. (Original) The computer program product of claim 33 wherein the program code for determining a quant with which to encode the frame further comprises:

program code for, prior to determining the quant, normalizing the fullness of the segment corresponding to the type of frame to encode, based on at least the segment size and the non-normalized segment fullness; and

program code for determining the quant as a function of at least a base quant envelope and the normalized segment fullness.

38. (Original) The computer program product of claim 37 further comprising:

program code for adding the counter of unallocated over/underflow bits to the buffer segment corresponding to the type of frame to encode, to an extent that the buffer segment is not overflowed or underflowed; and

program code for retaining any over/underflow bits that cannot be added to the segment in the counter.

39. (Original) The computer program product of claim 32 further comprising:

program code for, after encoding each frame of the video sequence, determining whether the encoding of that frame causes a VBV buffer underflow;

program code for, responsive to determining that the encoding of that frame causes a VBV buffer underflow, adjusting the quant used to encode the frame; and

program code for re-encoding the frame with the adjusted quant so as to eliminate the VBV buffer underflow.